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Comparative Analysis of WEEE Recovery Strategies and the WEEE Treatment Status in China and Romania

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Abstract

The growth of requirements on electrical and electronic equipment (WEEE) market in the world entails numerous consequences that are found in Romania and China. One of them is the increasing number of waste (WEEE) due to increased life, due to evolution of the technical process and to a wide range of equipment they produce. In terms of environmental pollution and changing of climate, this is a major problem due to toxic materials that are used in fabrication. So, WEEE is a common problem of Romania and China.

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Keywords: Waste Electrical and Electronic Equipment (WEEE); recycling; environment; pollution; hazardous materials.

1. Introduction

The increasing amount of electrical waste, led to reforms in recycling. Technological explosion and the growth of requirements on protective materials, electrical appliances and household electronic beams (EEE) lead to a considerable decrease of natural resources.

The environment suffers from accumulation of waste that has been recovered but has not been stored properly. Environmental pollution is increasing risks regarding ecosystem health and most important is the increasing risks in human health. A good plan can improve or slow down pollution.

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China had in the past two decades a rapid economic growth, due to development in the world market of goods for personal use and due to industrial and infrastructure development and urbanization of the country. Rising waste problem exist also in Romania, because the country is producing and consuming and EEE is on growing economy.

On the occurrence and development of WEEE management system involved the need to fully comply with the European Commission due to Romania's EU integration in 2007. There is a need regarding a collaboration of Romania, a country integrated into the European Union, with China, a country with strong impact on the production of EEE, in combating the accumulation of WEEE is of paramount importance.

The success of this collaboration would be getting a visible decrease in EEE waste containing more than 1000 different substances entering the hazardous and non-hazardous category. A few of them are: glass, ceramics, concrete, rubber, plastics, plastic additives, lead, mercury, chlorine, bromine, etc. biologically active materials. Some of these metals are valuable and could be recycled if they would use technology for their processing.

2. Numerical analysis of the two countries

In the European Union, the amount of waste from electronic and electrical equipment increased by 16-28% every five years. After an estimate the average lifespan of electrical equipment is about 7-8 years for TV, refrigerators and washing machines for 8-10 years and 10-11 years for air conditioning.

It was estimated that if all equipment freezing and the air conditioning should be properly recycled, the environmental impact by eliminating greenhouse gas emissions could drop by 200 million tons of CO2 between 2011-2020. When referring to global production of notebook PCs, China produces 77% and desktop PCs 21%.

In Table 1 we can see a history of major appliances that have occurred in China during 1990-2003. Results from these categories TV, PC, refrigerator, washing machine, air condition shows that the number of devices used increases very rapidly.

By the end of 2012, the ITC estimated that industry will generate 53 million tons of electronic waste (Sinah 2010). For example computers and landline phones are the morally impaired. By 2015 waste from household appliances will increase rapidly due to the end of the operation. According to Huisman (2007) report generated EEE waste of Romania will increase during 2010-2020.

Table 1. Electrical and electronic equipment units in China.

Electrical and electronic equipment units in China per year (thousands)					
Year	PC	TV	Refirigerator	Washing machine	Air-condition
1990	-	-	-	9417	99
1991	-	21250	6920	8846	259
1992	105	25685	8307	10352	650
1993	611	28258	9765	7562	1425
1994	849	28541	9751	9500	1618
1995	750	33506	13570	15219	2808
1996	1216	28811	11117	8004	3234
1997	1269	32321	11383	10834	4007
1998	2890	40881	10787	10980	4759
1999	3871	44493	12322	13395	5503
2000	7088	44600	11865	12613	7515
2001	7550	48429	19385	13336	9600
2002	7882	55731	-	-	10350
2003	9600	42291	-	-	11800

Source "W. He et al. / Journal of Hazardous Materials B136 (2006) 502–512"

According to the National Environmental Protection Agency and National Institute of Statistics the main economic activities of hazardous waste in Romania are:

- Mining and quarrying (extractive industry);
- Manufacture of wood and wood products and cork;
- Manufacture of coke, refined petroleum;
- Manufacture of chemicals and chemical products;
- Metallurgy;
- Metallic construction and metal products;
- Manufacture of machinery and equipment;
- Transport means, etc.

In Table 2 one can see the quantities of hazardous waste generated in Romania by main industrial activities in the period 2004-2008.

Table 2. Quantities of hazardous waste generated by the main industrial activities.

	Quantity-thousand tons				
Economic activity	2004	2005	2006	2007	2008
Extractive industry	1.214,4	997,18	497,59	11,24	31,11
Manufacture of coke, refined petroleum	431,1	419,72	226,35	37,89	114,53
Manufacture of chemicals and chemical products	55,8	41,95	47,11	53,33	54,02
Metallurgical	383,5	95,43	168,76	121,62	150,78
Manufacture of machinery and equipment	39,8	14,83	33,05	26,67	28,58
Transport industry	23,5	30,72	26,19	31,06	13,33
Other activities	23,4	74,36	53,76	137,28	42,59
Total	2.262,8	1.733,97	1.052,81	419,08	434,94

Source "National Environmental Protection Agency and National Institute of Statistics"

Romania has taken steps to collect waste electronic and electrical equipment. A study done in 2010 shows the amount of waste collected in Romania in 2008, 2009, 2010, 2011, 2012. This is found in Table 3.

Table 3. Total quantities of WEEE colected.

Country	Total quantities of WEEE collected in 2008	Total quantities of WEEE collected in 2009	Total quantites of WEEE collected in 2010	Total quantites of WEEE collected in 2011	Total quantites of WEEE collected in 2012
Romania	19.900	35.800	24.000	19.000	16.500

Source "2010 final annual report" weeelabex (www.weee-forum.org)

According to it, the amount of IT equipment sold in Romania during 2003-2007 is presented in Table 4, and in Table 5 WEEE is forecasted.
It was noted that Romania recorded the highest growth rate from one year to the other.

Table 4. Tone of IT equipment sold in UE27 (tones)

Country	2003	2004	2005	2006	2007
Romania	8.627	12.198	16.818	18.612	21.470

Source: United Nation University, 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipament (WEEE).

Table 5. Forecasted WEEE quantities (coming from households) for EU27 (tones)

Country	2010	2014	2015	2020
Romania	134.670	165.403	174.466	226.702

Source: United Nation University, 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipament (WEEE).

Prediction of annual obsolescence of four categories of household appliances and personal computers in China in 2011-2015 is found in Table 6.

Table 6. Prediction of annual obsolescence of four categories of household.

	Number of obsolete items (10 000 units)				
Year	Color Television sets	Household refigerators	Household washing machines	Air conditioners for rooms	Personal computers
2011	3251.85	973.45	1280.54	3668.45	10796.10
2012	3917.88	1086.99	2530.44	2524.40	16190.75
2013	4041.73	2094.18	1374.37	3875.04	24251.37
2014	4251.48	1242.00	1673.12	2992.61	90491.88
2015	4449.13	1714.78	1519.46	3250.11	80904.88

Source " Status quo e-waste management in mainland China"

At EU level there are big differences regarding the amount of waste from EEE that were collected from 4 kg per capita which was the target of the European Directive of 2002. Eurostat figures show that there are countries which have made great efforts to reach 8 kg per capita, these are: Austria, Ireland, Norway, Belgium, Sweden, Finland. The other extreme in which the indicator reaches at least 1 kg per capita is Romania. Community Studies (Eurostar, Husiman 2007) show that even if there is a legislation in 2002 to 24 kg per capita from EEE waste are generated annually, only 33% are collected and treated. Another 13% of them end up in landfills, while the remaining 54% are treated in accordance with the standards inside and outside the European Union.

According to statistics in Romania, in 2006 were put on the market value of 140.849.25 tons of EEE (data recorded and reported by 564 producers) and only 1,131 tons were collected. According to data from Eurostar about 382 kg of municipal waste were generated per capita in Romania in 2008, an estimate in 2011 of up to 2.74 million tons, for the end of 2012 up to 2.46 million tons and in 2013 a maximum of 2 200 000 tones (Source Larive Romania IBD 2011).

As a result of the average duration of life, different from the 2009, amount of EEE put on the market which does not become waste in the same year and in different years. Even if the China issue amount of waste per capita is only about 1 kg, it takes a large scale, taking a rapid growth of WEEE. Thus China has become the largest field of EEE waste discharge, accommodating more than 70% of WEEE annually worldwide. In Fig.1 is centralized data from Romania and China and it was collecting data on these estimates for the years 2009 to 2015, supposing that the system would be efficient collection of the most advanced systems currently available.

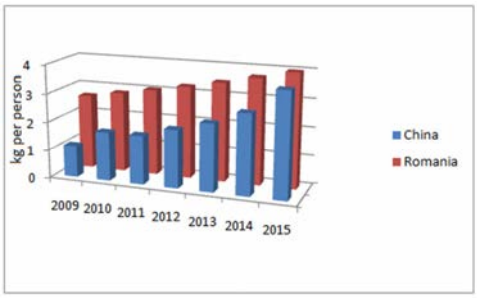

Fig. 1. The amount of WEEE in China and Romania reported in kg per person Equations
Source: "National Research Institute for Environmental Protection-ICIM Bucharest 5369/2006"; "Electronic waste from Wikipedia" and "People's Daily 20th edition"(2011.5.26)

3. Legislation and how to report them

Electrical and electronic equipment or EEE is defined as equipment whose proper functioning is dependent on electric currents or electromagnetic fields and equipment for generation, transmission and measurement of such currents and fields and designed for use with a voltage less than or equal to 1000 volts AC or 1.500 volts DC. *(source article 3 letter b, of the Decision no. 1037 October 13, 2010).*

The waste in Romania is defined as: any substance or any object in the category established in Law 426/200, on which the holder discards or intends or is required to throw them. Wastes contain more than 1.000 substances that are toxic or less toxic. 50% of EEE waste consists of iron and steel, followed by 21% plastic, 13% non-ferrous metals and other compounds.

In Romania, the development of EEE waste management system was spurred by the need to align the country to European Union requirements. European council and European Parliament launched EU Directive on Waste in 2002, where several European countries have been receptive to recycling of WEEE. The first directive in Romania was given in the Emergency Ordinance no. 68 of July 16, 2000.

Provisions of the Directive fully transposed by different laws are:

- Electrical and electronic equipment waste-implementation was done by GEO. 78/2000 on waste, approved and amended by Law no. 426/2000;
- Recovery-transposition was made by GEO. 78/2000 on waste, approved and amended by Law no. 426/2000;
- Removal-transposition was made by GEO. 78/2000 on waste, approved and amended by Law no. 426/2000;
- Dangerous substances and chemicals–transposition made by GEO. 200/2000 on classification, labeling and packaging of substances and chemicals, approved by Law no. 451/2001.

(Source Appendix 4- Implementation Plan for Directive 2002/96/EC on electrical and electronic equipment waste).

The objective of the ordinance is to regulate waste management activities under the protection of human health and environment. This brought a great influence on the performance management system in Romania on WEEE.

The European Union Directive which came into force in 2004 had clear objectives:

- to reduce the amount of WEEE;
- to increase recovery of WEEE through reuse, recycling, processing, energy recovery and disposal by incineration or disposal;
- concerning the producer of EEE, to have extended liability for the entire life cycle of the equipment.

The legislation which is now in force in Romania is the decision no. 1037 October 13, 2010 regarding the electrical and electronic waste, which brings additions and changes to the old law. It aims to improve the environment protection efficiency, the population health as well as to improve all those aspects involved in the life cycle of electrical and electronic equipment such as: manufacturers, importers, distributors, consumers, operators who are directly involved in collection, treatment, recycling, recovery and environmentally sound disposal of EEE waste. Some milestones in the new legislation:

Manufacturers to introduce into production those EEE that can be removed and recovered, and to foresee the reusability and recycling of WEEE, their components and materials. They have the liability to organize, manage and coordinate the separate collection of electrical and electronic equipment waste from private households;

It prohibits final disposal in landfills of WEEE;

Achieve a nationwide selective collection rate of at least 4 kg / inhabitant / year;

When entering an EEE on the market after the effective date of this decision, each manufacturer must submit a warranty to demonstrate the financing of the management of all WEEE from EEE products on the domestic market;

Manufacturers are obliged to provide users with the information they need in order to minimize the disposal of WEEE as unsorted municipal waste and to facilitate their selective collection by introducing an appropriate symbols.

Ministry of Environment and Forests keeps a register of manufacturers, in order to collect annual information, including estimations on how much has been manufactured and recovered from WEEE.

China, in September 2003, through State Environmental Protection Administration of China (SEPA) has announced a legislation regarding the waste from EEE. In December 2004 the law was revised and improvements were made on dismantling, recycling and disposal of EEE waste. This law was adopted in order to promote cleaner

production, reduce and avoid the generation of pollutants, increase resource efficiency, environmental protection and improvement, ensure public health and promote sustainable development of economy and society. By clean production, the Chinese state wants to reduce pollution, increase resource efficiency, use clean energy and raw materials, adopt techniques, technologies and advanced equipment, improve management by clear and specific directives, and other measures.

This law also aims the waste disposal, by prohibiting EEE waste to be stored directly in deposits. Dismantling, use and disposal of electronic waste is made only at specialized workplaces. These workplaces will have the conditions for the selective collection of waste and liquid collection equipment, without producing harm to workers or environmental damage. In order to eliminate electronic waste will first be eliminated lead-acid batteries, nickel cadmium, mercury switches, cathode ray tubes, PCB capacitors, refrigerants, which are a large source of pollution these being considered the most dangerous EEE waste. After the collecting and selection part follows the storage of the waste in specially designed storage containers. Next step resides in the use or disposal of the waste that cannot be used. This law includes certain prohibitions: it prohibits the use of retrograde technology or obsolete techniques and equipment; it is banned outdoor burning of electronic waste; electronic waste disposal is prohibited through direct storage.

Manufacturers, importers and sellers of EEE products must comply with the law and establish a system for recovering discarded equipment, take care also on how they are recovered and stored that they do not cause environmental damage. Toxic and harmful substances that EEE may contain are: Lead, Mercury, Cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDE).

Dismantling, use and disposal activities should respect the requirements of standardization, technical and political criteria of the State Environmental Protection Administration to prevent and control pollution with waste from EEE. Regulations on Administration of recovery and disposal of EEE waste dated on January 1, 2011, is addressed to the EEE waste disposal qualification candidates which are bound to meet the following conditions:

- Have sound facilities for waste electric and electronic product disposal;
- Have plans for proper use or disposal of waste electric and electronic products that are unable to be fully disposer of;
- Have sorting, packaging and other equipment appropriate for the waste electric and electronic products to be disposed of and;
- Have professional technical personnel in relation to safety, quality and environmental protection.

(Source: Regulation on the Administration of the Reconvery and Disposal of Waste Electric Electronic Products.)

In accordance with Directive 199/31/CE and Government Decision no. 162/2001, Romania must reduce the amount of biodegradable municipal waste deposited annually, compared with 2001, to 35% by 2017.

4. Strategies for collaboration

The EEE wastes contain complex mixture of dangerous and safe materials consisting in economic value items that need collecting, separation, transport, treatment and disposal. To understand how many items become waste after their use, such as a mobile phone for example, the people from Umicore have conducted a study (Source Umicore 2008). The components are from Mendeleev's Periodic Table: H, Li, K, Be, Mg, Sr, Ba, Y, Ti, Zr, Ta, Cr, Mo, W, Fe, Ru, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, B, Al, Ga, In, C, Si, Sn, Pb, N, P, As, Sb, Bi, O, S, F, Cl, Br, F, Cl, Br. *(Source Nokia).*

There is a reticency coming from Chinese and Romanian people concerning the payments for WEE waste recycling and their disposal services, especially when the consumers can produce money by selling them as second-hand products. The Romanian scrap irons dealers are collecting equipments with future potential of being sold, but all these are not well - organized and they survive just by invoking the profit and survival reason. President Ecotic's declaration from 2009 shows that the illegal amount sold by Romanian in the third world through European ports has reached 10, 000 tones annually.

An important factor who could lead to a successful collaboration between China and Romania concerning the WEEE administration would be the integration of informational system. Another factor who could lead to an important reform in both countries would be the awareness of the WEEE dangers between the consumers, the collectors, those who recycle. Energy can be saved by recycling the iron and plastic items from WEEE, instead of

wasting it by discarding them in piles of litter who wouldn't represent any value at all. For example, the recycled copper needs 85% less energy, and recycled steel 74% less energy than their extractive and refinery processes out of raw material. These are valuable materials that could be recycled through suitable technologies.

The best and most efficient procedure concerning the EEE waste collecting is door-to-door. In the past 3 years the number of educational and informing campaigns has considerably grown, therefore, in 2008, 96% of domestic waste had been collected by traditional methods. The local authorities as well as the Sanitation Services have to invest more in waste collection network. The biggest investments in recycling and WEEE treatments are constituted by the new waste treatment installations.

The WEEE collection purpose, which is 4 kg per person per year in Romania and 1 kg per person per year in China has to be a priority. Romania has got problems concerning this issue, because the study made by Romanian authorities has revealed that only 1-1.5 kg waste per person, obtained from WEEE, had been collected in 2010. Recycling is another matter, of course.

The issue, the two countries are facing is Environmental Pollution, at a high rate especially in China, in the most populated cities. Environmental protection strategies through analyses, supervisions and predictions could lead to WEEE reforms. The two countries could work together towards implementing a new program for an adequate and efficient release, use and EEE waste disposal, monitoring the impact on the environment.

5. Conclusions

The electric and electronic equipment waste is a real problem for the entire world. Romania and China are two countries who have recently started to follow the countries that fight for a correct procedure of WEEE toxic material disposal and storing in direct warehouses.

The most stimulating factor for a cooperation between the two countries is pollution, who has had an impact on environment and in peoples' health. Recovery of new metals and other WEEE materials consumed today can be reached through new methods and performing devices. By their recovering energy consumption can be lowered, especially pollution reduction.

China, as a big EEE producer, and Romania, as a EEE consumer are obliged to take action to collect, treat, dispose and deposit the EEE waste. Technology is rapidly developing and EEE market demand is increasingly higher, that's why its final period is becoming closer and we have to invest time, energy and money to solve the issue.

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